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THE HOUSE FLY IN ITS RELATION TO PUBLIC HEALTH

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I.

INTRODUCTION.

The importance of the study of insects in many departments of human interest is being the more fully recognized as science reveals the facts of interrelationships, both advantageous and destructive. Mosquitoes and flies have for centuries past been looked upon as a source of extreme annoyance to the human family, but that these insects might be transmitters of disease was hardly even suspected until the latter part of the last century. (King, '83.) That insects and arachnids of a given species might be the sole transmitters of a specific disease, and, what is more, a necessary factor, inasmuch as these forms serve as intermediate host, was not considered seriously until the latter five years of the last and the beginning of this, the twentieth century. (See sundry papers by A. Laveran, R. Ross, R. Koch, P. Manson, B. Grassi et al.; all on malaria and its causative organism.) There have now appeared literally hundreds of isolated papers relating to the transmission of disease by insects, and we are at this time obliged to recognize the new subject which we term Medical Entomology. (Herms, '09*d*.) This field embraces phases of the study of medicine, mainly the etiology and pathology of such diseases as malaria, yellow fever, sleeping sickness, filariasis, etc., of bacteriology, inasmuch as the causative germ must be studied, and of entomology, inasmuch as the mouthparts and other structures of the insect must be known as well as its systematic relationships.

There need be no question as to the justification of our investigations in this ever broadening field when the economic loss to mankind is considered. One need but consult the timely and valuable paper by Dr. L. O. Howard ('09) entitled "Economic loss to the people of the United States through insects that carry disease," to be impressed with this enormous loss. Doctor Howard states, "Entirely aside from the loss occasioned by mosquitoes as carriers of specific diseases, their abundance brings about a great monetary loss in other ways. Possibly the greatest of these losses is in the reduced value of real estate in mosquito-infested regions, since these insects render absolutely uninhabitable large areas of land available for suburban homes, for summer resorts, for manufacturing purposes, and for agricultural pursuits." (See, also, Herrick, '03.) The expense to the United States incurred in the purchase of fly traps, sticky fly paper, fly poison and the like, must certainly exceed

two millions of dollars annually, while Howard ('09) estimates the cost of screening at over ten millions of dollars per annum. The commercial value of a human life is estimated on the average at three thousand dollars. The decrease in the vital assets of this country through typhoid fever alone (much of which is transmitted by the house fly or typhoid fly) amounts to $350,000,000. (Felt, '09.)

The California State Board of Health in "The California Sanitation Exhibit, 1909," writes as follows: "California loses annually 5,000 citizens from tuberculosis, 500 from typhoid fever, and 500 more from diseases caused by infected milk and food supply. This means that approximately one out of every five residents eventually dies from one of these diseases contracted through personal or public failure to provide the essentials of sanitary environment. * * * The six thousand deaths which could be prevented by the enforcement of public health laws represent an annual loss of $18,000,000 per year to the State, in addition to the personal and social losses which can not be estimated in terms of money."

Malaria, typhoid fever, yellow fever, bubonic plague, sleeping sickness, cholera, are all preventable diseases, carried wholly or in part by insects. The enormous sums of money spent in the temporary control of these diseases might well be spent in a more effective manner, i. e., directed toward the root of the evil—at the cause. "Eliminate the cause, you eliminate the effect." This is the service that medical entomology is to afford—its aim is the control of disease transmitting insects. The most vulnerable point in the life history of the insect is sought, and the most effective methods of control are then applied.

FIG. 1.—Head of the stable fly, *Stomoxys calcitrans*, illustrating the type of piercing mouthparts which relate to the *direct* transmission of pathogenic organisms. The sheath or *labium* encloses slender, piercing bristles.

METHODS OF DISEASE TRANSMISSION.

Broadly speaking, there are two methods of disease transmission in which insects are concerned, namely, a *direct* and an *indirect* method, based on the structure of mouthparts. The direct method depends upon piercing mouth structures (Fig. 1) capable of penetrating the animal skin and introducing

into the circulation a pathogenic organism. The indirect method is based on the accidental accumulation of pathogenic organisms upon foot or mouth structures and introducing these on the food of the human being, relating mainly, therefore, to intestinal diseases, such as typhoid fever, Asiatic cholera, and dysentery. Other than this, insects may act as parasites, both external (lice, etc.) and internal (bot-flies, etc.) causing irritations and disease, or they may produce wounds by the introduction of a specific poison through the bite, as does the bedbug, the kissing bug, and the like.

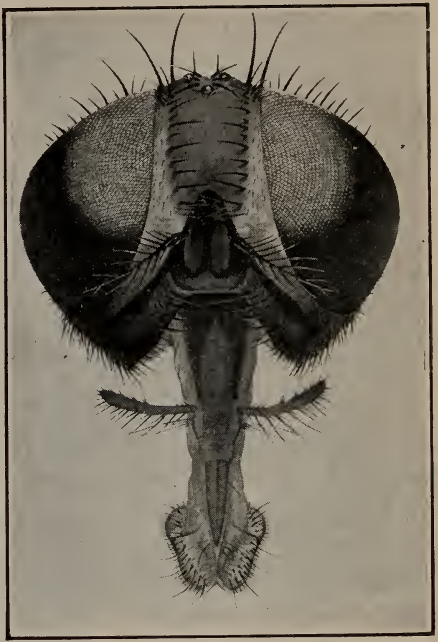

FIG. 2.—Head of the house fly, *Musca domestica,* illustrating the type of suctorial mouthparts *not* adapted to piercing the human skin; but because of the presence of numerous bristles and hairs a good collector of filth and germs relating to the indirect transmission of disease.

Two common insects will serve to illustrate the two principal methods, namely, the stable fly (Fig. 3) on the one hand—the direct method; and the house fly (Fig. 4) on the other—the indirect method. The former possesses mouthparts which are adapted to penetrate the skin (Fig. 1), introducing into the blood pathogenic organisms which attack the red corpuscles or other liquid portions of the body, such as the cerebro-spinal fluid. The stable fly is known to transmit a Trypanosome disease (Surra) of the Philippine Islands (Laveran et Mesnil, '04); a closely related genus the *Glossina* or Tsetse fly transmits other Trypanosome diseases, such as sleeping sickness. (Laveran et Mesnil, '04.)

The second type (indirect) is represented by the house fly (Fig. 4), an important transmitter of intestinal diseases, because it is readily attracted to excrementous matter, vomit and sputum, collecting there the "germs" upon its mouthparts (Fig. 2) and feet and then carrying them to the food of human beings, thus readily causing infection. The house fly, notwithstanding public opinion, can not pierce the skin since its proboscis is quite fleshy and not equipped with piercing bristles. It is the stable fly which inflicts the wound, as may be seen by a careful examination of the mouthparts as shown in the illustration (Fig. 1), but because of the mutual resemblance the house fly is blamed.

Thus we see that the usual method of insect classification, that of

biting and sucking insects, does not apply in this work, since the two forms mentioned, namely, the house fly and the stable fly are both suctorial, and, indeed, very closely related systematically, yet they relate very differently to disease transmission.

It is wise for the student of medical entomology to note the distinction between the vegetable pathogenic (disease producing) organisms, such as the bacteria, and the animal pathogenic organisms, such as the *Protozoans,* since the two classes vary considerably in their longevity and virulence when outside the human body, and behave differently within the bodies of different insects, e. g., typhoid fever is a bacterial disease, the causative germs of which outside the body are present in the excrement and urine; malaria, on the other hand, is a *Protozoan* disease which can not live outside the human body, except in the mosquito of the genus *Anopheles.* Similar contradistinctions might be made between tuberculosis and African sleeping sickness, the pathogenic bacterial organism of the former present outside the body largely in the sputum, and the protozoan pathogenic organism of the latter present in the body of the *Glossina* (Tsetse) fly, having previously been sucked up with the blood by this sucking fly. Again, bubonic plague is a bacterial disease, while Texas fever and the African tick fever are protozoan types.

FIG. 3.—The stable fly, *Stomoxys calcitrans,* enlarged.

FIG. 4.—The house fly, *Musca domestica,* enlarged.

WHAT IS THE HOUSE FLY?

Properly speaking, only one species of fly (*Musca domestica* Linn, Fig. 4) is rightly called the house fly, though there are several species which invade the house, either regularly or at times. A brief account of these latter species may be useful here by way of comparison. The blow fly or blue bottle fly (*Calliphora vomitoria,* Fig. 5) is the large, noisy fly seen frequently on the window and about meat. This is typically a flesh fly, depositing its eggs on the meat in the pantry or elsewhere, finding the proper food for its larvæ often in the most protected situations. The female often deposits its eggs in proximity to meat and the larvæ on hatching crawl to this food. While the blow fly is conspicuous it is not as plentiful as the house fly, and is not as liable to be found walking about on the prepared foods of man.

FIG. 5.—The blow fly or blue bottle fly, *Calliphora vomitoria,* enlarged.

FIG. 6.—The flesh fly or green bottle fly, *Lucilia Caesar,* enlarged.

Another flesh fly conspicuous because of its bright metallic green color is the green bottle fly (*Lucilia Cæsar,* Fig. 6). This insect rarely comes into the house, and seldom remains long, owing to its rapid response to differences in light intensities. (Herms, '09 *d* and *e.*) It is typically a fly of the out-of-doors, and a very good scavenger. (Herms, '07.)

The stable fly (*Stomoxys calcitrans,* Fig. 3), as has already been mentioned, is often confused with the house fly because of its close

resemblance, but the structure of the mouthparts will serve to readily distinguish the two. (Figs. 1 and 2.)

Several other flies are commonly found indoors, but are not readily distinguished from the common house fly; only careful examination of the wing venation and other minute characters can serve to correctly identify the species. Several species belonging to the following genera, *Pollenia, Morellia,* and *Muscina* belong to the same family as the house fly, namely, *Muscidæ,* while others, such as *Homalomyia* and *Anthomyia* (Fig. 7), belongs to another family,

Fig. 7.—Anthomya fly (enlarged), whose larvæ are known as root maggots. This fly is often found indoors and closely resembles the house fly.

Fig. 8.—Wing of the house fly, *Musca domestica,* illustrating the typical wing venation of the *Muscidae.*

namely *Anthomyidæ.* The wing venation of the two families is quite characteristic, as illustrated by the two figures. (Figs. 8 and 9.) The cell, marked with an x, is more or less completely closed in the *Muscidæ,* and is open in the *Anthomyidæ.*

Fig. 9.—Wing of the Anthomya fly, *Anthomyia radicum,* illustrating the typical wing venation of the *Anthomyidae.*

LIFE HISTORY OR DEVELOPMENT.

By life history is meant the development of the organism from the egg to the adult. The house fly belongs to that group of insects which passes through a complex metamorphosis unlike that of the grasshopper, for example, which gradually grows up to the adult without changing much in general form. The house fly, on the other hand, passes through several stages, each unlike the other, namely, the egg, the larva (mag-

got), the pupa (resting stage), and the imago or full grown winged insect. (Fig. 10.)

From 75 to 125 eggs are deposited singly in one mass, and there are usually several (2 to 4) such layings. Excrementous material, especially of the horse, is the favorite place upon which the eggs are deposited. Other suitable situations are kitchen refuse, unused brewer's grain, and other decaying vegetable matter. Where the city garbage is carefully disposed of with only ordinary attention to horse manure it seems quite safe to say that ninety-five per cent of the house flies are bred in the latter situation. (An effort made to breed these flies in the laboratory in cow manures proved unsuccessful, but adults were reared from full grown larvæ and pupæ collected in and near the manure pile from the dairy, showing that the house fly may breed in this material, though

FIG. 10.—Illustrating the life history of the house fly: *a* egg stage; *b* larval stage or maggot, full grown; *c* resting stage or pupa; *d* the imago or adult.

probably only to a limited extent.) The eggs hatch in from twelve to twenty-four hours and the newly hatched larvæ begin feeding at once.

To gain an estimate of the number of larvæ developing in an average horse manure pile, samples were taken from such a pile after an exposure of four days with the following results: First sample (4 lbs.) contained 6,873 larvæ; second sample (4 lbs.), 1,142; third sample (4 lbs.), 1,585; fourth sample (3 lbs.), 682; total, 10,282 larvæ in 15 pounds. (Herms, '09.) All these larvæ were quite or nearly full grown. This gives an average of 685 larvæ per pound. The weight of the entire pile was estimated at not less than 1,000 pounds, of which certainly two thirds was infested. A little arithmetic gives us the astonishing estimate of 455,525 larvæ (685 x 665), or in round numbers, 450,000. This particular manure pile (not from a livery stable, either), was only one of many known to exist in various parts of the city. No wonder flies fairly

swarm in the vicinity of these choice ornaments! Five samples of an ounce and a half of manure each furnished the following numbers, viz.: (1) 58 larvæ, (2) 64, (3) 70, (4) 228, (5) 49. Total, 469 larvæ to seven and one half ounces, an average of nearly *one thousand per pound.*

The larval stage is the growing period of the fly and the size of the adult will depend entirely upon the size that the larva attains. An underfed larva will result in an undersized adult, which fact is well illustrated by Fig. 11, based on experiments tried on the flesh fly, *Lucilia Cæsar.* (Herms, '07.) This growing stage requires from four to six days, after which the maggots often crawl away from their breeding place, many of them burrowing into the loose ground just underneath the manure pile, or crawling under boards or stones, or into dry manure collected under platforms and the like. (One and three fourths pounds of dry manure, taken from a situation last mentioned, contained 2,561 pupæ.) The larvæ often pass three or four days in the prepupal or migrated stage before actually pupating; but in a given set of individuals under similar conditions the various stages are remarkably similar in duration, when one pupates the rest will certainly follow in short order, and when one emerges as an adult others quickly appear. The average time required for development is differently estimated by various observers, inasmuch as temperature greatly influences the time required. Packard ('74) gives the time at from ten to fourteen days, Howard ('06) at Washington, D. C., as ten days. In Berkeley, where the weather is uniformly cooler (rarely above 80° and a mean of 48° during the winter months) the life cycle is completed usually in from fourteen to eighteen days, less often in twelve days. Prolonged cool weather or

FIG. 11.—Illustrating the effect that underfeeding the larva has on the size of the adult fly (*Lucilia Caesar*). Overfeeding, if it does not result fatally, does not increase the size of the fly over the Optimum, as may be seen by the uppermost individual, which is the same size as the next lower individual or Optimum. Each of the next lower individuals is the result of decreasing the time of feeding by six hours. These results are based on a large number of individuals in each case.

artificially cooled environment results in greater retardation. Even allowing for such retardation, the number of generations produced during the summer is quite large and in California (Berkeley) I have seen house flies emerging from their breeding places during every month of the winter season. This latter fact lends even greater importance to a house fly campaign. In early March a veritable pest of flies was encountered while on a trip through the Imperial Valley (California). When the fly emerges from the pupa case with fully developed wings, it is as large as it ever will be, except in expansion of tissue and addition in weight, due to stomach contents or development of eggs in the female. This explains why no young house flies are seen (young in the sense of being small). The little flies upon the windows are not ''baby'' flies, but belong to another species, also adult. One can easily influence the size of a fly by underfeeding it in the larval stage, as illustrated in Fig. 10 (see Herms, '07). The question has been asked, ''Why are all house flies so nearly of one size?'' This is not altogether true. There are some undersized house flies, but the greater majority of the larvæ or maggots find ample food for optimum development. Furthermore, experiments show that the house fly is not as plastic in respect to food conditions as the flesh fly, for instance: in other words, larvæ which are underfed perish easily.

In order to determine the distribution of the sexes, observations were made under two different conditions, viz., first, six sweepings with an insect net were made over a horse manure pile on which many flies had gathered (the results are shown in Table I); second, all but half a dozen flies were collected in one house, giving a fairly representative lot for indoors, even under screened conditions. (See Table II.)

TABLE I.

Showing results with regard to sexes and species in six sweepings from a horse manure pile on May 18 and 19, 1909.

	First.		Second.		Third.		Fourth.		Fifth.		Sixth.		Total.	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
House fly (*Musca domestica*)	7	153	4	81	3	64	9	77	4	210	5	112	32	697
Muscina stabulans	2	6	0	7	0	5	2	5	3	10	1	4	8	37
Blow fly (*Calliphora vomitoria*)	2	2	0	1	1	0	0	0	0	0	1	0	3	3
Lucilia Cæsar	0	1	0	1	0	1	0	1	0	0	0	0	0	4
Other species*	1	4	0	4	2	1	4	2	4	2	2	0	13	13
Totals	12	166	4	94	6	71	15	85	11	222	9	116	56	754

*Including *Anthomyids* and *Scatophagids,* but excluding many tiny *Diptera,* probably *Sepsis.*

TABLE II.

Showing number of individuals collected in a screened dwelling June 1, 1909.

	M	F
House fly, *Musca domestica*	86	116
Muscina sp.	3	1
Homalomyia sp.	5	0
Calliphora	1	2
Totals	95	119

Explanation and comparison of Tables I and II.—These two tables give us some information as to the relative abundance of the house fly, and the distribution of the sexes. Table I shows clearly that of those flies which frequent both the manure pile and the home, the house flies compose 90 per cent, and that of the total collected, over 95 per cent (95.4 per cent) were females. Thus, it is clear that it is the "instinct" to oviposit (to lay eggs) that has mainly attracted these insects to this situation. In fact, fresher parts of the manure pile are often literally white with house fly eggs in countless numbers. Observations made in the near vicinity of the manure pile proved that certainly the same percentage (over 95 per cent) of the flies clinging to the walls of the stable, boxes, and so on, were males.

Of the total number of house flies (202) collected indoors (June, '09), representing all but perhaps six of the total number in that particular house, 57 per cent were females, showing nearly equal distribution for the sexes. This would, it seems, indicate that the sexes of this insect are equally attracted to the house by odors issuing therefrom. Another interesting point is that of the total number of flies thus collected indoors (214), 94.4 per cent were the common house fly. This estimate can not, of course, be taken as a standard. The number is entirely too small, but it does come very near the percentage determined by Dr. L. O. Howard (Howard, '00), who "made collections in the dining-rooms in different parts of this country, and out of a total of 23,087 flies, 22,808 were *Musca domestica,* that is 98 per cent of the whole number captured."

That the sexes in the housefly are normally about equal in number is apparent, inasmuch as of a total of 264 pupæ collected indiscriminately and allowed to emerge in the laboratory, 129 were males and 135 were females. The author has, however, made observations on the flesh flies, *Lucilia Cæsar,* and *Calliphora vomitoria,* which indicate that the factor of underfeeding must be considered in this connection. From a large amount of unpublished data, it seems evident that underfeeding results

in the emergence of a greater percentage of males; this does not mean, however, that sex is influenced by feeding, it only means that cutting short on food supply destroys the larval females first. Feeding experiments, not yet complete, on the house fly indicate that the same holds true here, but also that this insect is not so plastic as the flesh fly, hence does not vary so greatly in size and dies more easily when underfed.

Anatomical considerations are here omitted, inasmuch as that phase of the subject is admirably treated in a work by Hewitt ('07).

RELATION TO DISEASE TRANSMISSION.

We should be familiar with the actual method of disease transmission by the house fly. Some insects act as intermediate host for pathogenic organisms, which latter can not exist sexually and be transmitted without the insect, e. g., the malarial fever parasite (*Plasmodium malariæ* and other species), which passes part of its life history in the body of the *Anopheles* mosquito. The house fly, as far as known, is not an

FIG. 12.—Foot of the house fly greatly enlarged. Note the many fine hairs with which the foot-pads are provided.

intermediate host necessary to the life history of a pathogenic organism, but is by accident of habit and structure one of the most important and dangerous of disease transmitting insects. In habit the house fly is revoltingly filthy, feeding indiscriminately on excrement of all kinds, on vomit and sputum, and is, on the other hand, equally attracted to the daintiest foods of man, and will, if unhindered, pass back and forth between the two extremes. The house fly's proboscis (Fig. 2) is provided with a profusion of fine hairs which serve as collectors of germs and filth; the foot of the fly when examined under the microscope

presents an astonishing complexity of structure, illustrated in Fig. 12. Each of the six feet is equally fitted with bristly structures and pads, which secrete a sticky material, adding thus to their collecting powers. This structural condition, added to the natural vile habits of the house fly, completes its requirements as a transmitter of infectious diseases.

This creature has long been known to contaminate food, but has, nevertheless, been regarded as a scavenger, and thus as a real servant of man, but if there remains any doubt in the mind of the reader, after reading what follows, as to the necessity of getting rid of this wolf in sheep's clothing, let him take the time to make a few careful observations for himself.

Circumstantial evidence against the house fly as a transmitter of such infectious diseases as typhoid fever, tuberculosis, dysenteries, and cholera is complete as summed up thus: First, it possesses the best possible structures for the conveyance of "germs" and filth; second, it possesses the habit of feeding on excrementous matter of all kinds, vomit and sputum; third, the causative organisms ("germs") of the above named diseases are present in the matter mentioned in the second clause; fourth, the house fly is the principal fly found in dwellings, alighting upon the prepared food of man, or on food products in grocery stores, fruit stands and meat markets.

Experimental evidence that the house fly actually does carry bacteria upon its mouthparts and feet or in its intestinal tract is not wanting. To illustrate, the following simple experiment may be cited.

In order to show that the house fly (*Musca domestica*) can carry "germ" of a known kind, a partly sterilized fly was placed in a test tube containing a culture of *Micrococcus aureus*. After walking about in this tube and becoming contaminated with the *Micrococci,* the fly was transferred to a sterile agar-agar plate upon which it was allowed to crawl about for three minutes. The plate was then incubated for twenty-four hours, after which it was examined and photographed, as shown in Fig. 13.

The photograph shows the trail of the fly as it had walked about. Every place that the foot touched is plainly marked by a vigorous bacterial growth. That the fly can not easily get rid of all the bacteria on its feet is also illustrated by this photograph, inasmuch as three minutes spent crawling about on the agar plate did not apparently lessen the growth-vigor of bacteria deposited, and a second plate of agar-agar contaminated by the same fly immediately after exposure of the first plate gave equally striking results. The same experiment was performed, using the *Bacillus prodigeosus* with even more pronounced results, as shown in Fig. 14. These experiments were repeated several times with like effect.

A second series of experiments was carried on as follows: During the midde of May (1909) house flies were captured in various parts of Berkeley, placed at once in sterilized vials, and in the laboratory placed under bell jars with agar-agar plates, all under sterilized conditions. After the flies had crawled about on the culture media, the latter was incubated for twenty-four hours. In every case, but one, a strong growth of bacteria appeared. This one was incubated longer and after forty hours four centers of infection appeared. This fly had been taken on a sunny wall on one of the main streets, and having been under

FIG. 13.—Cultures of *Micrococcus aurens* transferred by a house fly to a sterile agar-agar plate upon which it was allowed to crawl for three minutes. Incubation period 24 hours.

observation in this position for a long time (as reported by the assistant) it was first supposed that the action of the sunlight had sterilized it. This series of experiments included flies taken from a number of situations, namely, principal thoroughfares, sunny walls, street corners, manure piles, and the dining-room. Without exception these flies were laden with bacteria, and in all cases the greatest care was exercised not to introduce any accidental infection on to the culture plates.

Probably the most accurate study of these factors was carried on by Esten and Mason (Esten and Mason, '08) on the "Sources of Bacteria

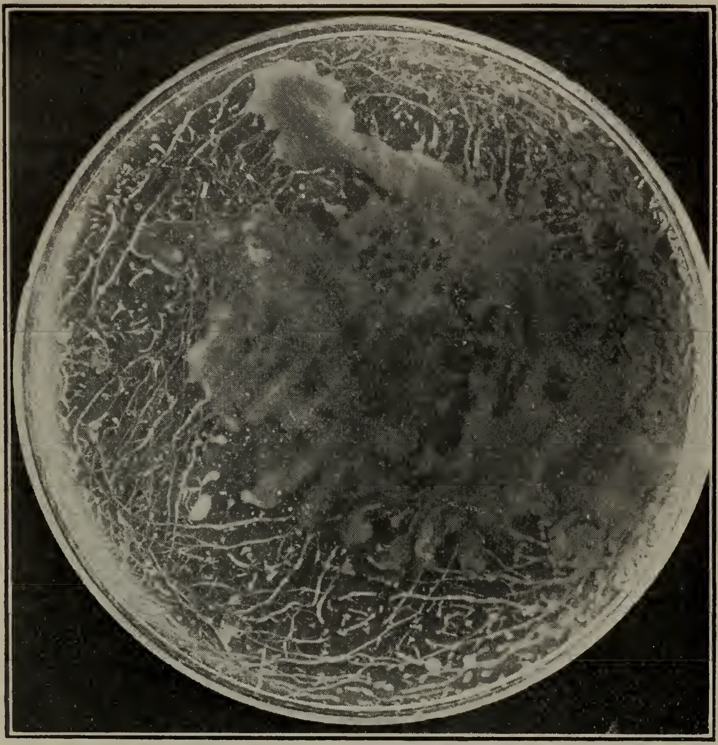

FIG. 14.—Cultures of *Bacillus prodigeosus* transferred by a house fly to a sterile agar-agar plate upon which it was allowed to crawl for only a few moments. Incubation period 24 hours.

in Milk," and certainly most striking facts were revealed. The following table and attached remarks are taken from that publication, and need no further comments or explanations:

TABLE III.

*Sources of bacteria from Flies.**

1907.	Source.	Total number.	Total acid bacteria.	Rapid liquefying bacteria.	Slow liquefying bacteria.	Bacterium lactis acidi, Group A, Class 1.	Coli-aerogenes, Group A, Class 2.
July 27	[a] 1 fly. Bacteriological laboratory	3,150	250	600	100	----------	----------
July 27	[b] 1 fly. Bacteriological laboratory	550	100	----------	----------	----------	----------
August 6	[c] 19 cow stable flies	7,980,000	220,000	----------	20,000	----------	----------
	Average per fly	420,000	11,600	----------	1,000	----------	----------
August 14	[d] 94 swill barrel flies	155,000,000	8,950,000	----------	----------	4,320,000	4,630,000
	Average per fly	1,660,000	95,300	----------	----------	46,000	49,300
August 14	[e] 144 pig pen flies	133,000,000	2,110,000	100,000	266,000	933,000	1,176,000
	Average per fly	923,000	18,700	700	1,150	6,500	12,200
September 4	[f] 18 swill barrel flies	118,800,000	40,480,000	----------	14,500,000	10,480,000	30,000,000
	Average per fly	6,600,000	2,182,000	----------	804,000	582,000	1,600,000
September 21	[g] 30 dwelling house flies	1,425,000	125,000	----------	12,500	----------	----------
	Average per fly	47,580	4,167	----------	417	----------	----------
September 21	[h] 26 dwelling house flies	22,880,000	22,596,000	120,000	34,000	----------	----------
	Average per fly	880,000	869,000	4,600	1,300	----------	----------
September 27	[i] 110 dwelling house flies	35,500,000	13,670,000	8,840,000	125,000	----------	----------
	Average per fly	322,700	124,200	80,300	1,100	----------	----------
August 20	[j] 1 large blue bottle blow fly	308,700	2,200	mould spores		----------	----------
	Total average of 414 flies	1,222,570	367,300	7,830	73,500	----------	----------
	Average per cent of 414 flies	----------	30%	6%	6%	----------	----------
	Average per fly of 256 flies, experiments [d], [e], [f]	3,061,000	765,000	230	268,700	211,500	553,800
	Average per cent of 256 flies, experiments [d], [e], [f]	----------	25%	----------	8%	7%	18%

*Esten and Mason, '08.

"From the above table the bacterial population of 414 flies is pretty well represented. The domestic fly is passing from a disgusting nuisance and troublesome pest to a reputation of being a dangerous enemy to human health. * * * The numbers of bacteria on a single fly may range all the way from 550 to 6,600,000. Early in the fly season the numbers of bacteria on flies are comparatively very small, while later the numbers are comparatively very large. The place where flies live also determines largely the numbers that they carry. *The average for 414 flies was about one and one fourth millions bacteria on each.* It hardly seems possible for so small a bit of life to carry so large a number of organisms. * * * The objectionable class, coliærogenes type, was two and one half times as abundant as the favorable acid type."

TYPHOID FEVER.

The causative organism (*Bacillus typhosus*) of typhoid fever belongs to a group known as the typhoid-dysentery group, and is found outside the human body "only in those situations where it could be more or less directly traced to an origin in the discharge of a typhoid patient or convalescent." Jordan ('08) and others have shown that the life of this germ in the water of flowing streams is of comparatively short duration, and that multiplication does not ordinarily take place in water; indeed, a steady decline in numbers goes on. Infection caused by transmission through the air is exceedingly rare according to these authors, but soil on the contrary may become contaminated through buried human excrement, or otherwise, and continue to be a source of infection for a much longer time than water. Notwithstanding these facts, the majority of typhoid fever epidemics are traceable to water infection, but indicate fresh contamination and not one of long standing.

Within the human body the typhoid bacilli are found mainly in the intestine, and also in the urinary bladder, and in the majority of cases are present in the blood stream (Jordan, '08). The bacilli are discharged from the body with the fæces and the urine; and are often present in such discharges for a period of ten weeks, and in chronic carriers for at least two years after recovery. An added source of danger is the presence of virulent bacilli in light cases of typhoid fever, known as the "walking typhoid," where little or no precaution is exercised, but which may result in the severest types in others infected from such individuals.

These facts aid in interpreting the rôle of flies in typhoid transmission. Flies are attracted by excrementous matter, as has already been stated, and subsist entirely upon liquid foods, thus contaminating their mouthparts and feet, which, if the fæces contain virulent bacilli, must now fairly reek with filth and disease. Thus equipped the fly next makes its way to the dining-room of man or to grocery stores, fruit stands, etc., depositing there through the digecta or by means of the

soiled proboscis and feet the typhoid bacillus upon the food which is eaten by the human family. Thus, during the Spanish-American war (Veeder, '98), flies with lime-covered feet were actually seen crawling over the food of the soldiers. The whitened feet were the result of lime and filth collected from the camp latrines. The depredations of typhoid fever at that time really mark the beginning of the widespread campaign against the house fly.

Jordan ('08) states, "not only may bacilli stick to the legs and wings of these insects, but if swallowed they may survive the passage of the alimentary tract. Typhoid bacilli have been isolated from house flies captured in houses in Chicago, in the neighborhood of badly kept privy vaults used by typhoid patients, and it has been shown experimentally that living bacilli may remain in or upon the body of flies for as long as twenty-three days after infection."

The writer's attention was called to a series of sporadic cases of typhoid fever, plausibly traceable to flies, thus: a certain carpenter recently recovered from typhoid fever, resumed his work, making use of a box privy, such as is often used in connection with buildings under construction. In the immediate vicinity there lived a milk dealer, who, after washing his cans, placed them on the roof of a shed to drain and dry. Flies are fond of milk, even highly diluted with water. The cases of typhoid fever in question were, on investigation, found to be customers of this particular dealer. The argument is good and reasonably conclusive.

The pollution of the waters of New York harbor has been made the object of special study by Jackson ('09). In his report to the "Merchants' Association" of New York, he shows that the sewage is not carried away by the tides, and "that at many points sewer outfalls have not been carried below the low-water mark, in consequence of which the solid matters from the sewers have been exposed on the shores." These deposits were found to be covered with flies, thus affording ample opportunity for the transmission of typhoid. It was, furthermore, found that the greater number of typhoid cases were found near the water front, and if the curve showing the prevalence of cases was set back two months it coincided with the curve showing the prevalence of house flies. The period of two months represents the time of incubation. The fly curve, of course, also coincides with the temperature curve, but hot weather alone can not account for the dissemination of the typhoid bacillus.

DYSENTERY.

There are at least two varieties of dysentery; one of which is caused by a bacillar organism, as in typhoid fever, and is known as *Bacillus dysenteriæ* and the other variety is caused by a protozoan organism (entomœba), known as *Entomeba histolytica*.[2] The former variety is

[2]Jordan loc. cit. p. 430.

known to be the prevalent type in temperate climates, while the latter is commonest in the tropics. The causative organisms of both are found in great numbers in the stools of patients. The mode of infection is without doubt the same as mentioned in typhoid fever, and in which the house fly also certainly plays an important rôle.

SUMMER DIARRHEA IN INFANTS.

A type of *Bacillus dysenteriæ*[3] is present in the stool of infants suffering from summer diarrhea. Thousands of infants die every summer from this complaint. It is well known that flies are strongly attracted by the stools from infants thus affected, and in the second place, consecutive to the argument, little children are greatly molested by flies, inasmuch as they often have milk vomits on their little dresses and around the mouth attractive to flies, and are quite helpless. How often does one see the house fly lingering menacingly around the mouth of the helpless infant. Keep the flies away from the babies by the use of screens and nettings, and thus avoid in great measure the most dreaded disease of the infant. Do not permit the flies to crawl around on the child's face and hands.

TUBERCULOSIS.

Tuberculosis is caused by a specific organism, *Bacillus tuberculosis,* which may invade practically every organ and tissue of the human body. The lungs are commonly the seat of lesions, as are the intestines, the liver and the urogenital organs. The causative germs find their way outside the body through the sputum, the fæces, and the urine, depending on the location of the lesions.

In the study of transmission the considerable powers of resistance which these bacilli possess are highly important. Dried phthisical sputum has been found to contain still virulent bacilli (or their spores) after two months. Sputum has been found to contain living tubercle bacilli even after being allowed to putrefy for several weeks. (Muir and Ritchie, '07). Sunlight is ordinarily a good disinfectant, killing bacteria very quickly when properly exposed, but it requires, as Jordan states, from twenty to twenty-four hours or even longer to kill the tubercle bacillus when present in sputum.

These facts are most important when, coupled with them, it is recognized that recent investigations prove that infection is possible through the intestinal tract, by way of infected food introduced into the mouth. Thus, flies are known to feed readily on sputum of tuberculous individuals, and, as in typhoid fever, may deposit the bacilli upon human food.

"Von Behring maintains that the vast majority of all cases of lung tuberculosis are of intestinal origin, and there is no doubt that pulmo-

[3]Jordan pp. 284-285.

nary tuberculosis can originate from swallowing tubercle bacilli.'' (Jordan, '08.)

It has been proved beyond doubt that the house fly can carry with it in its intestinal tract the bacillus tuberculosis. ''The belief that flies (*Musca domestica*) which have fed on tubercular sputum may serve as carriers and disseminators of the tubercle bacillus first led Spillman and Haushalter (1887) to investigate the problem. They examined such flies and also their excreta deposited on the walls and windows of a hospital ward, and were able to determine microscopically the presence of large numbers of tubercle bacilli, both in the intestines of the flies and their excrement.'' (Nuttall, '99.) Howard ('09) in a bulletin already cited, quotes the following from ''a paper by Dr. Frederick T. Lord ('04) of Boston'':

1. Flies may ingest tubercular sputum and excrete tubercle bacilli, the virulence of which may last for at least fifteen days.

2. The danger of human infection from tubercular flyspecks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from fly specks is unlikely. If mechanically disturbed, infection of the surrounding air may occur.

As a corollary to these conclusions it is suggested that—

3. Tubercular material (sputum, pus from discharging sinuses, fæcal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies, lest they act as disseminators of the tubercle bacilli.

4. During the fly season greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis, and laboratories where tubercular material is examined.

5. As these precautions would not eliminate fly infection by patients at large, foodstuffs should be protected from flies which may already have ingested tubercular material.

The investigations by Dr. Ch. André, of the University of Lyons, were reported upon at the Anti-Tuberculosis Congress at Washington, 1908, viz.:

The results of this investigation are as follows:

Flies are active agents in the dissemination of Koch's bacillus because they are constantly going back and forth between contagious sputa and fæces, and foodstuffs, especially meat, fruit, milk, etc., which they pollute by contact with their feet, and especially with their excretions.

The experimental researches of the author show the following:

1. Flies caught in the open air do not contain any acid-fast bacilli that could be mistaken for the bacillus of Koch.

2. Flies that have been fed on sputum evacuate considerable quantities of bacilli in their excretions. The bacilli appear six hours after ingestion of the sputum, and some may be found as long as five days later. These flies, therefore, have plenty of time to carry these bacilli to a great distance, and to contaminate food in houses apparently protected from contagion, because not inhabited by a consumptive.

3. Food polluted by flies that have fed on sputa contains infective bacilli and produces tuberculosis in the guinea pigs.

4. Flies readily absorb bacilli contained in dry dust.

5. Flies caught at random in a hospital ward produce tuberculosis in the guinea pig.

Practical Conclusions.—The sputa and fæces of tuberculous subjects must be disinfected; flies should be destroyed as completely as possible; foodstuffs should be protected by means of covers made of wire gauze.

ASIATIC CHOLERA.

Asiatic cholera, as the name indicates, is endemic in Asia (India), but has spread over the larger part of the world during the past century, appearing as epidemic in Africa and Europe. The disease relates to the intestinal tract, and is of bacterial origin (*Spirillum choleræ*). The cholera spirillum leaves the body with the stools, and infection is traceable to this source. "Upon the surface of vegetables and fruits kept in a cool moist place, experiments have shown that the spirillum may retain its vitality for from four to seven days." (Jordan, '08.)

Cholera was one of the first diseases with which flies were associated as transmitters, and the experimental evidence that has since been produced is no less complete than in typhoid fever. Without advancing the evidence as presented by Nuttall ('99), the following statement made by that eminent authority will serve the purpose, viz.: "The body of evidence here presented as to the rôle of flies in the diffusion of cholera is, I believe, absolutely convincing."

OTHER DISEASES TRANSMITTED.

The pus forming or suppurative bacteria (*Staphylococci*) are largely carried by the house fly. Thus, the suppurative eye disease of Egypt is said to be transmitted by the common house fly (Nuttall, '99), while Florida sore eye, or "pink eye," is evidently directly traceable to a little fly having mouthparts similar to the house fly known as the *Hippelates* fly (Nuttall, '99).

Under certain conditions it is very probable also that the house fly may transmit leprosy, erysipelas, anthrax, smallpox and framboesia (Yaws). Dr. E. P. Felt ('09) writes, "it is held that flies may under certain conditions convey plague, trachoma, septicemia, erysipelas, leprosy, and there are reasons for thinking that this insect (the house fly) may possibly be responsible for the more frequent new cases of smallpox occurring in the near vicinity of a hospital."

The experimental evidence against this insect is accumulating rapidly, and the next five years will without doubt mark the addition of other diseases to the already appalling number ascribed to it, and further proof with regard to the last mentioned diseases as yet not well established.

OBJECTIONS MET.

The annihilation of a species, whether complete or relative, always brings opposition on the part of not a few persons. Few ideas are more firmly rooted in the mind of the average man or woman than that Nature has brought forth nothing that is useless in the economy of the human family. It is time and again asserted that this or that insect, though it is known to be disease transmitting, must be good for something, other-

wise it would not be in existence, and should, therefore, not be exterminated or even molested. In answer to this, it should be said that parasitism is quite certainly an acquired habit. Organisms now parasitic have not always been so, though they can not now well exist in any other way. The carelessness of man (frequently downright uncleanliness) results in the provision of a favorable environment for parasites. Certainly no one would contend that it is necessary to be infested with lice, or even that the bed must be infested with bedbugs. Yet the principle is the same relative to the house fly, which breeds, as has been pointed out, in excrement and refuse. Again, since it has been so conclusively proved that certain kinds of mosquitoes transmit malaria and others yellow fever, it will not be contended that it is a breach of trust against Nature to exterminate the mosquito, and thereby the causative organism of malaria and yellow fever. Some have said that the house fly acts as a scavenger, and is, therefore, a friend of man. *The house fly is the poorest of scavengers, and one of the most dangerous of man's enemies—a veritable wolf in sheep's clothing.* As innocent as these creatures may appear, the evidence as revealed by scientific methods, shows them to be monstrous carriers of disease. There is no virtue in the house fly; there is no reason why it should continue to exist, and its death knell is being sounded wherever communities care for the health of the individual. Dr. E. P. Felt ('09) has said "our descendants of another century will stand in amazement at our blind toleration of such a menace to life and happiness."

The following is an extract from a letter recently received, which illustrates well the objections frequently raised:

DEAR SIR: I enclose a slip that I cut from a paper saying that you are down on the poor flies. Now, I would like to take their part. I have known them nigh on to thirty years, and I never knew of a sickness that could be laid to them. I know they make a lot of dirt, spoil picture frames and such, tickle your nose in the morning if you don't get up, but they make a nice food for young poultry. * * * Only a few years back they were considered a blessing, as they eat stuff that would make harm. * * * they spot things, make a lot of cleaning that keeps folks out of mischief. If mosquitoes or fleas harm any one, it's because the blood is out of order, and they had better look to it and mend their ways. * * * I think if you would get after them of your size, such as ——— and ———, they are parasites that do more harm than insects and reptiles combined. * * * so if you want to scrap go after them. * * * this torturing poor helpless creatures to find ways to prolong lives that are worthless * * * we all must die some way * * * hoping you will let the flies and little things alone. * * *

Unfortunately, there are men in every community who claim to be exponents of hygienic progress, but who oppose any agitation of this sort, claiming that it will give a bad name to their city, town or village. "Why people will think this must be a dreadful place in which to live." As a matter of fact, such men belong in the same category with the farmer who asked the question with the I've-got-you-now spirit, "What will our chickens do without maggots if you exterminate the house fly?"

A sane body of business men, such as compose the "Chamber of Commerce" of any community would surely not begin a "house fly campaign" if it were in sympathy with such individuals as we have just quoted.

ESSENTIALS OF CONTROL.

Methods of control are planned along the lines set forth by the study of the life history and habits of the insect. The more familiar we are with regard to these two factors, the better equipped are we to cope with the problems of control. The most vulnerable point in the life history must be determined, and then the most effective insecticide applied, or, what is better, the most useful preventive methods employed either in the elimination of the breeding place of the insect, or the protection of the same by mechanical or chemical means to prevent the deposition of eggs, thus producing ultimately the local annihilation of the species.

The following statements are taken largely from a publication by the author (Herms, '09 *b*) on "The Essentials of House Fly Control," issued by the Berkeley (Cal.) Board of Health.

The house fly can be controlled without question. This is demonstrated by the scarcity of flies in localities where cleanliness about stables and houses prevails through a number of adjacent city blocks. The work of control can be greatly furthered by the individual citizen; indeed, the California State Board of Health in Bulletin No. 11 (1909), makes the following statements: "This work can be done only by a united effort. The citizen must do the work, and should do it willingly, but, if negligent, the strong hand of the law should compel it." The citizen must, however, have instruction in the matter since there is the greatest ignorance relative to the life history and development of the house fly and disease transmitting insects in general. The writer finds that this ignorance is as prevalent among the educated as among the uneducated.

The main facts pertaining to development and habits indicate the most desirable control measures to be pursued. If more than 95 per cent of our house flies develop in the manures of horses, and there is no question that this is true, and the rest in kitchen refuse, garbage and excrement of man, the point of attack is clearly outlined.

The open manure pile *must* be abolished and stables *must* be kept clean. House flies breed in large numbers in the cracks of the stable and stall floors, where manure falls between. This calls for the use of cement, or other tight floor with proper provision for drainage. Receptacles containing kitchen refuse must be kept tightly closed to prevent the female fly from depositing her eggs there.

Permanent preventive measures will always be far less expensive in the end, and also very much more effective than the use of temporary

methods in the form of insecticides, which must be applied repeatedly with continuous expenditure of time, labor and money. Domesticated animals are necessary in our present civilization, but the methods of disposing of manures and caring for stable sanitation has remained in most cases where it was a century or two ago. Where many horses are stabled, a closet to receive manures can be built at a small cost. This closet *must* be kept closed, except when the offal is being placed therein and when it is being removed. The closet may be built in one corner (preferably a dark one) of the stable, with a small screened door through which the manure is thrown when cleaning the stalls (providing also

Fig. 15.—Type of manure closet used in connection with the University of California horse stables. This receptacle would have been far more effective had it been built in the form of a lean-to, connecting directly with the stables by means of a small screened door, thus dispensing with the open outside lid.

for ventilation), and an outer door giving access to clean out the closet once or twice a week. A photograph of a manure closet adjoining one of the university barns is shown in Fig. 15. Such a closet may be built in the form of a shed to the stable, connecting therewith by means of a screened door as above, or the closet may take the form of a screened pit in the darkest corner of the stable. The darkness will help to keep away the flies also. The floors of these closets or bins should be tight so as to prevent seepage of the manure outside. A form of manure pit, not so practical, however, as the above, constructed of concrete, is shown in Fig. 16; a form used in the Berkeley Fire Department houses. Where

only one horse is stabled, the manure may be conveniently placed in ordinary garbage cans and stamped down, or in tight barrels covered with a well fitting lid or wire screen.

A very serious objection to several of these bins may be raised, in that the wide open door provides access to the flies during the time manure is being thrown in, and once inside the flies deposit their eggs and development proceeds. Thus, where the contents of the bin is not emptied at least once a week, and then perhaps not thoroughly scraped out, a veritable breeding cage results. Obviously, this can be remedied by frequent and careful removal of manure from the bin, but the most satisfactory way is to construct a shed or lean-to, as already mentioned,

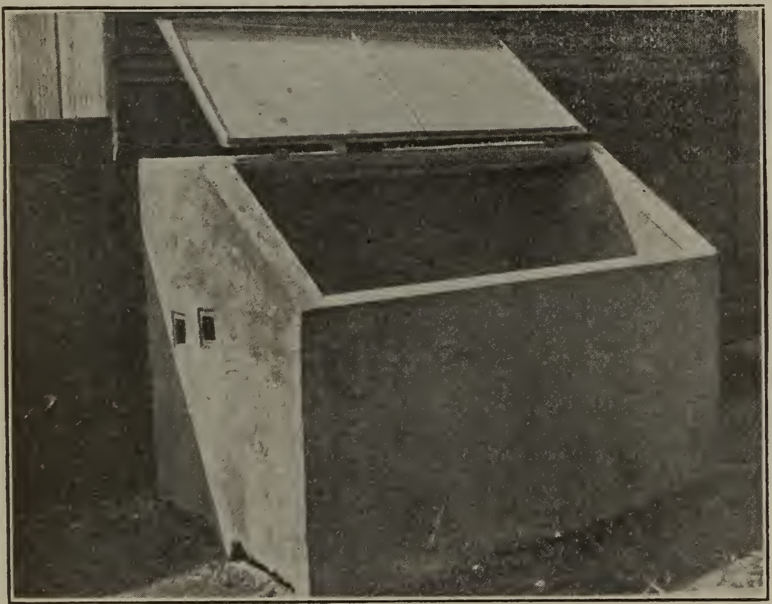

Fig. 16.—Photograph of a concrete manure bin constructed at one of the local fire department houses. Removal of the manure is rendered difficult because it must be lifted out. The heavy metal lid is also inconvenient.

with only a small opening through which the manure is thrown. This opening should be near the darker end of the stable and should be screened.

The object of all this procedure is to prevent the deposition of eggs by the flies on the manure or other offal which is to provide food for the young. On the ranch it is often possible and certainly advisable to remove the stable manures every morning, by merely backing a cart to the stable door and depositing therein the material and hauling it to the field at once, where it is scattered. The manure should in all cases be scattered upon the field and not be allowed to accumulate there in heaps. Thinly scattered manure does not favor the breeding of flies

because of lack of moisture. Farmers and gardeners who wish to use decayed manure for fertilizing purposes should screen the heaps until the decaying process is well under way, when fly breeding will be reduced to a minimum. Stable yards and empty town lots used for horses are a source of many flies. Here the droppings from the horses accumulate and are kept moist by the urine from these animals, thus affording good breeding places. *The stable yard and town lot used for horses must not be overlooked in the campaign against the house fly.* Merely sweeping up the manure with a broom, or superficial shoveling without scraping up the loose earth, will not remedy the matter greatly. It must be borne in mind that when the larvæ have fed sufficiently for full growth, a period of four or five days after hatching from the eggs, they crawl into the loose earth underneath the manure pile (often great pockets of larvæ may be found thus), or they wander to loose débris in the immediate vicinity, many, of course, remain in the manure pile to complete their life cycle. Thousands of pupæ (recognized as chestnut colored, barrel-shaped individuals) were taken by the writer in one instance from underneath a platform leading into the stable. Thus, when cleaning up, these conditions and situations must be taken into account.

Human excrement, if left uncovered, furnishes another good breeding ground for the house fly (Howard, '00). The dung in open privies should be treated thoroughly with "chloride of lime," or even an ounce of kerosene will serve well; either must be applied at intervals of three or four days at the height of the season. Indiscriminate defecation in alleyways and little frequented situations should be considered a misdemeanor punishable by a heavy fine, for the reason that house flies breed also in human excrement and especially because of the very great danger of infection by means of flies. In communities where there is no sewer system, the "dry earth" closet is most satisfactory and should be required by ordinance.

Unused brewer's grains and mashes, when dumped as waste in the field or on the premises, afford a famous place for the fly to develop. Oftentimes this is used as feed for cattle, and what is left over is simply dumped on to the field. Often this waste food is the greatest source of flies around dairies.

Guinea pig pens and rabbit pens may become prolific breeders of flies if they are not carefully cleaned.

INSECTICIDES.

FLY LARVÆ IN MANURE PILES.

Manure piles and other offal already infested with fly larvæ should be treated with an insecticide before removal in order to kill the developing generation. The purchase of insecticides for continuous use would be a matter of no small cost, especially because of the tenacity of life shown by fly larvæ and the consequent strength of insecticide necessary to kill them. Ordinary applications of the usual insecticides prove of no avail. The cheapest, and at the same time most effective, preparations must be applied in strengths two to five times that which is useful against other insects, and furthermore the larvæ can not be easily reached buried as they are in the bedding and offal. In the face of these conditions the more reliable and really simpler methods mentioned above are recommended.

Chemicals used to destroy the larvæ may be roughly divided into two classes, viz., (1) contact poisons, and (2) stomach poisons. To the first class belong such preparations as kerosene and cresol, also chloride of lime. To the second class belong the arsenicals represented by arsenate of lead and paris green.

Where the manure pile can be spread out to a depth of about half a foot it may be drenched with a distillate petroleum, which possesses a high flash point, i. e., does not ignite easily, and has the necessary insecticidal property. The petroleum oils sold as proprietary compounds on the market as "Miscible Oils," "Spray Emulsions," and the like, should be applied at the rate of one part of the oil to ten parts of water. *If kerosene oils of a low flash point are used about stables and outbuildings the danger from fire must be considered.*

The larvæ can also be destroyed by a compound made in the following manner and diluted at the rate of one part of the compound to twenty of water. Great care should be exercised in the preparation and use of this insecticide, since it is corrosive and poisonous.

Formula: Dissolve one half pound caustic potash in one half pint of water, let stand several hours until dissolved and cold; add this to one quart of raw linseed oil contained in an earthenware vessel, stirring the while, and repeat the stirring process at intervals of about one hour for from four to five hours, then let stand over night. This process will result in a soap to which must now be added slowly, while stirring, one and a quarter quarts of commercial cresol, which will gradually dissolve the soap. Three or four days may be necessary to effect complete solution. For use, this compound must be diluted at the rate of

one part to thirty of water. The quantity given above will produce from 12 to 15 gallons. Apply to the manure pile or garbage. Poultry must not be permitted to feed upon the larvæ thus treated. (This liquid, used at the rate of one part to one hundred parts of water, is also serviceable as a germicide applied as a spray about poultry houses.[4])

Chloride of lime used on the manure pile is also effective, but, like the above, is expensive when used in proper quantities.

The use of arsenical poisons has not been thoroughly tested by the writer; indeed, he hesitates to recommend these materials for general use because of the danger to domesticated animals in and near the barn-yard, but the statements by Newstead ('08) are here repeated as an indication that the matter has not been overlooked. "The application of paris green (poison) at the rate of two ounces to one gallon of water to either stable manure or ashpit refuse will destroy 99 per cent of the larvæ. Possibly a smaller percentage of paris green might be employed with equally good results. One per cent of crude atoxyl in water kills 100 per cent of fly larvæ. The application of either of these substances might, however, lead to serious complications, and it is very doubtful whether they could be employed with safety."

Tobacco decoctions have been tried in various strengths without success; indeed, the fly larvæ seemed to thrive in the most concentrated solutions.

INDOOR WORK—THE ADULT FLY.

The adult female flies should, wherever possible, be prevented from depositing their eggs by the application of methods already described. Because of the great disease transmitting powers of the flies they should be kept away from human food. Screens must continue to be used until the community as a whole learns to apply the simple remedies to exterminate the fly, when screens will no longer be needed, and that time is not far off. The use of poisonous (arsenical, etc.) preparations upon which the flies may feed is not recommended, inasmuch as the poisoned insects often drop into foods, and, what is more important, many of these preparations are a menace to human life, especially to innocent children. Sticky fly paper, and certain traps, while disagreeable, still serve a good purpose. Good repellents of prolonged effectiveness are still wanting; experiments with a series of essential oils show that oil of lavender and oil of geranium have a limited effect when placed in shallow vessels on the dining-room table, for example.

For indoor *spraying* it is highly desirable that the insecticide have the following attributes: (1) Non-poisonous to higher animals, including man; (2) non-corrosive to higher animals, including man; (3) effective as a germicide as well as an insecticide; (4) cheap; (5) non-repulsive odor to man. Another attribute: (6) repellent, would add much to its

[4]Maine Agricultural Experiment Station Bulletin No. 165.

value. Numerous sprays scoring from one to three points were experimented with, but in all cases the effectiveness was more pronounced on blow flies than on the house fly, and in all cases the labor involved was not inconsiderable.

As already referred to, the use of fly poisons is objectionable for the reason that flies are liable to fall into food or the poison itself might be drunk by children, with possibly fatal results. The writer has found (as already suggested by others) that formaldehyde, properly used, forms a very good substitute for arsenical or cobalt poisons. Various dilutions and combinations were used, but a 2 per cent strength when sweetened somewhat with sugar or honey (or even without sweetening) proved most desirable. Formaldehyde is inexpensive when used as indicated, and has the added advantage that it is not poisonous to man in weak concentrations, and may, therefore, be used with impunity in this form around food. It is also one of the most powerful germicides known, and is not injurious to delicate fabrics. Formaldehyde as purchased at the drug store is in about a 40 per cent solution and should be diluted with water down to about 2 per cent (add about twenty times as much water). The solution should be placed in shallow vessels on the window sills, on the table or in show windows. It is not an easy matter to control the fly in a dining-room where there is plenty of liquid material for food and drink, such as water, milk, sweets, etc., but when this can be removed or covered up in the evening and the dishes of formaldehyde then put in place, the flies will drink this the first thing in the morning and the end will be accomplished much more readily. One is here taking advantage of the fact that the fly seeks something to drink early in the morning.

Various fumes created by burning one or the other of the following materials will stupefy the flies—pyrethrum power (*Persian pyrethrum* or *Chrysanthemum cineraria folium*), Jamestown weed leaves (dried) (*Datura stramonium*) mixed with crystals of saltpetre. The fly-fighting committee of the American Civic Association recommends the following: "Heat a shovel, or any similar article, and drop thereon 20 drops of carbolic acid; the vapor kills the flies."

OTHER PRECAUTIONS.

It is highly important that sick rooms should be well screened, especially in case of transmissible diseases. For the protection of the outside world any flies that chance to find their way inside after the best precaution has been exercised should be killed to prevent their possible escape. Pus rags, bandages, sputum, cloths, and the like, should not be carelessly thrown into the open garbage barrel where flies freely congregate. It may seem unnecessary to even mention these simple sanitary

measures, but the writer has seen the grossest neglect in matters of this kind, even where better judgment should have prevailed.

THE COMMUNITY-WIDE CAMPAIGN.

To carry out the suggested permanent preventive measures and other methods, a community should to begin with have an appointed staff of instructed inspectors, the number varying with the size of the community; four capable men working in pairs can cover considerable territory very well. After the primary steps have been taken, the number can be reduced to the regular number of sanitary inspectors, provided they know their business. No community should be without regular, instructed sanitary inspectors under the direction of the board of health. The position of sanitary inspector should carry with it some dignity, and should be filled by men instructed in practical hygiene, including a fair knowledge of medical entomology, inasmuch as the importance of insects in their relation to disease transmission is rapidly gaining ground.

The author's interest in "flies" from a scientific standpoint dates back some eight or nine years, during which time he has been collecting data and carrying on specific investigations, a portion of which has been published, as already pointed out.

During the winter of 1908-1909, the writer accompanied the Southern Pacific demonstration train on several trips through California, lecturing on the general topic of medical entomology, but agitating especially the question of house fly control and mosquito control. The interest that this awakened was evidenced by many letters of commendation, and was marked by some effort to carry on the work by individuals, but the importance of community effort was at that time really not properly considered and recognized. However, in April, 1909, the following letter was received from the Secretary of the Berkeley Chamber of Commerce:

BERKELEY, CAL., April 8. 1909.

DEAR SIR: Knowing that you are interested in an attempt to suppress the house fly nuisance, it is my desire to enlist your aid for the relief of Berkeley.

This office is located between two livery stables that breed myriads of flies. The proprietors are not to blame, as they doubtless would coöperate to abate the nuisance. There are other stables that are similarly prolific. You can instruct the owners of stables how to apply a destroying agency. These flies if left undisturbed will scatter throughout the city to the detriment of the public health. I respectfully appeal to you to give this matter your attention, knowing that the people will gratefully acknowledge their indebtedness if afforded relief.

In answer to this letter an outline of campaign was submitted, which was reported upon by the secretary, viz.:

At a conference held at the rooms of the Berkeley Chamber of Commerce last evening it was resolved to begin a campaign against the pestiferous insects that usually come with the summer season. The campaign will be carried on under the

united efforts of the Berkeley Board of Health and the assistant professor in entomology, University of California, the latter to be assisted by more than twenty students, who will be appointed inspectors. These students wlil be appointed as deputy sanitary inspectors. and their work in the field will be devoted to discovering and suppressing places that if left uncorrected would become breeding places for flies, mosquitoes and other pestiferous insects.

Upon proper showing any objectionable place will be declared a nuisance, and the owners will be required to abate said nuisance.

Dr. J. J. Benton, Berkeley's Health Officer, and the other members of the Board of Health, are unanimous in commending the campaign, and declare that they will lend all aid in their power to rid Berkeley of these pests. Professor Herms will conduct a series of lectures and demonstrations on the demonstration plan, to show how flies and other insects are produced, and how they may be destroyed or prevented from coming into existence. It is proposed to make Berkeley a spotless town in this regard. Berkeley will be the first city in California to take such a step as this.

Outline of plan:

1. Educational lectures and demonstrations by Professor Herms at the Chamber of Commerce rooms. Newspaper agitation and discussion.

2. Coöperation of Board of Health. To declare breeding places of flies and mosquitoes a nuisance, and giving moral and legal indorsement.

3. Appointment of instructed inspectors. These are students in medical entomology. To be in charge of Professor Herms, medical entomologist. This is a new science that already has proved its value to the medical world. The inspectors are to make careful survey of stables, barnyards, pools, dumps where flies might breed, and will be vested with authority to give notice to abate nuisance. They will be regularly appointed sanitary inspectors, with legal power to serve in that capacity. They will give advice and instruction in regard to getting rid of flies. Ninety-five per cent of house flies come from horse manure. It is possible to eliminate this source of breeding almost altogether. With ninety-five per cent of the house flies destroyed or prevented from coming into existence the fly nuisance will be about eliminated.

4. Direct methods of control. In charge of medical entomologist. Application of insecticides; directed against: first, adult insects on premises; second, larvæ in process of development. Manure must be retained in fly-tight receptacles, and removed once a week. The garbage situation will be investigated and report made to Board of Health.

Each inspector was supplied with printed cards of the following form:

Street ______________________	No. ____________
Name ______________________	
Disposal of Garbage ______________	Standing Water ______________
Stables ________ Condition ________	Barrels ______________
Horses ______________	Pools ______________
Cattle ______________	Troughs ______________
Hogs ______________	Cess Pools ______________
Goats ______________	Vermin (Insects, etc.).
Dogs ______________	Flies ______________
Cats ______________	Fleas ______________
Rabbits ______________	Cockroaches ______________
Guinea Pigs ______________	Ants ______________
Poultry ______________	Sundry ______________
Pigeons ______________	Condition of Premises ______________
(Over) Sketch of Premises.	Nuisances ______________
	Inspector ______________

With the following ordinances (given here in part), together with the support of the police department, the campaign slowly but surely took shape:

ORDINANCE NO. 523*a*.

Regulating the depositing of dirt, paper, filth, sweepings, ashes, manure, garbage, or filthy water, offal or other refuse matter in the town of Berkeley.

Be it ordained by the Board of Trustees of the town of Berkeley as follows:

SECTION 1. It is hereby declared to be unlawful for any person to throw or deposit or to cause or to permit to be thrown or deposited any dirt, paper, filth, sweepings, or filthy water, offal, straw, wood, stones, earth, manure, refuse matter or rubbish of any kind whatever, into any avenue, street, way, lane, alley or public ground in the town of Berkeley.

SEC. 2. It is hereby declared to be unlawful for any person to throw into or deposit, or permit or cause to be thrown into or deposited upon any private premises in the town of Berkeley, except in covered metal or metal lined boxes or barrels, any garbage or filth, or refuse matter.

SEC. 4. Any violation of this ordinance shall be deemed a misdemeanor, punishable by a fine not exceeding fifty (50) dollars. The judgment imposing the fine may provide for its collection by imprisonment in the county jail of Alameda County, at the rate, in the manner and for the time provided by law.

STABLE ORDINANCE NO. 447*a*.

Regulating the erection and maintenance of stables in the town of Berkeley, and providing a penalty for the violation of said ordinance.

Be it ordained by the Board of Trustees of the town of Berkeley as follows:

SEC. 3. Where the premises on which any stable, barn, shed, or stall is maintained in which any horse, mule, or cow is kept, fronts on a street in which is constructed a sewer, the following requirements shall be complied with, viz.: The drainage from all single and box stalls where a horse, mule or cow is kept or housed, must in all cases be connected to the street sewer. The floor of all said stalls must be made impervious to water, and the drainage from said stalls must be conducted to the sewer either in tile or cement gutters, of a radius of not less than two inches. The said gutters shall discharge into a 3-inch or 4-inch trap before entering the main sewer. The trap must be protected in all cases by a strainer and be easy of access for cleaning purposes.

SEC. 5. All stables, sheds, barns, stalls, corrals, or stable yards in which any horse, mule or cow is kept shall be thoroughly cleaned out at the following intervals of time: Where stables, barns, sheds, stalls, corrals, or stable yards exist, they shall be cleaned out at least every day. The manure, offal, soiled straw or other refuse matter from all stables, barns, sheds, stalls, corrals, or stable yards shall be placed immediately upon removal from such stable, barn, shed, stall, corral, or stable yards in closely covered metal or metal lined receptacles, and kept covered until destroyed or removed from the premises. The contents of such receptacles shall be removed therefrom and disposed of at least twice a week.

SEC. 6. Any violation of this ordinance is declared to be a misdemeanor, punishable by fine of not less than twenty-five ($25.00) dollars, and not exceeding one hundred and fifty ($150.00) dollars. Each day's violation of the provisions of this ordinance shall be deemed a distinct misdemeanor and be punishable as such. A judgment imposing a fine may provide for its collection by imprisonment in the county jail of Alameda County, at the rate, for the time, and in the manner provided by law.

The Commissioner at the head of the Department of Public Health and Safety met with the Chamber of Commerce and the writer, informing himself fully on the progress of the campaign and the methods, at once undertook a tour of inspection about the city seeing the situation

for himself. The entire police force, under instructions both verbal and written, began at once to continue the work of sanitary inspection, issuing orders to abate nuisances wherever found. The chief of police gave his heartiest coöperation throughout. (See, also, Herms, '09.)

Communities in which a campaign against the house fly has been undertaken with determination to win have shown that the fly can be controlled. Sanitary laws must be enacted and rigidly enforced without fear or favor. The house fly can be controlled without question, and without great labor or expense. The problem is simpler than many are willing to admit, but it requires coöperation, and should have the willing support of every citizen. Everybody is concerned, and everybody will share in the victory and share in the saving of financial and vital losses.

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